ABSTRACT OF THE DISCLOSURE

A method, apparatus and system for template-controlled, precision laser interventions is described that greatly improves the accuracy, speed, range, reliability, versatility, safety, and efficacy of interventions such as laser microsurgery, particularly ophthalmic surgery, and industrial micromachining. The instrument and system are applicable to those specialties wherein the positioning accuracy of laser lesions is critical, wherever accurate containment of the spatial extent of a laser lesion is desirable, and/or whenever precise operations on a target or series of targets subject to movement during the procedure are to be effected. A key object of the present invention is to implement a fully integrated approach based on a number of different instrumental functions all operating in concert within a single, fully automated unit. Each of the complementary, and at times competing, functions requires its own technologies and corresponding subassemblies. The system includes a user interface, wherein the user can either draw, adjust, or designate particular template patterns overlaid on a live video images of the target (such as the cornea) and provide the means for converting the template pattern into a sequence of automatic motion instructions to direct a laser beam to focus sequentially on a number of points in three dimensional space which will, in turn, replicate the designated template pattern into the corresponding surgical or industrial site. The user interface also continuously presents three dimensional visual information to the surgeon/user during the operation, as to the surrounding features of the subject tissue, the topography of the surface to be operated upon or below said surface at a prescribed depth, and as to the precise aiming location and depth of penetration of the treatment laser beam. The system thus comprises the following key elements: (1) a user interface, consisting of a video display, microprocessor and controls,(2) an imaging system, which may include a surgical video microscope with zoom capability, (3) an automated 3D target acquisition and tracking system that can follow the movements of the subject tissue, for example an eye, during the operation, thus allowing the surgeon/user to predetermine his firing pattern based on an image which is automatically stabilized over time. Tracking is considered a critical element of the system designed not only to diagnose, but to also select treatment, position the treatment beam and image the tissue simultaneously with the treatment, while assuring safety at all times, (4) a laser, with which can be focused so that

only the precise lesions described by the user interface are effected. The laser parameters are selected to allow execution of the desired procedure at a high rate of independently targeted shots per second, as well as tuning to selectively generate photodisruption of tissues, or photocoagulation as desired, (5) a diagnostic system, incorporating a mapping and topography means for measuring precise surface shapes prior to and subsequent to a procedure, said measurements to be executed on-line within time scales not limited to human response times, and (6) a fast reliable safety means, whereby the laser firing is interrupted automatically, should any conditions arise to warrant such interruption of the procedure.